INTERNATIONAL BEST PRACTICE LEADING TO CERTIFICATION OF STANDARD IEC61850

Robison Díaz
CODENSA - Colombia
rdiaz@endesacolombia.com.co

Rodolfo García
CODENSA – Colombia
rgarcia@endesacolombia.com.co

Nelson Marín
CODENSA-Colombia
nmarinj@endesacolombia.com.co

ABSTRACT

Since the start of this decade, there has been massive migration of high-power substation control systems towards the use of protocol IEC 61850, which is regarded as a benchmark standard regarding power substation automation. The whole migration process (i.e. modernization) has brought new challenges, such as the need for implementing a specific IEC-61850 laboratory in Colombia so that compliance with and proper use of such a protocol can be easily verified. This new laboratory – which started operating in 2013 (run by Universidad Nacional de Colombia and supported by CODENSA) – represents an attempt to guarantee that the best possible benefits are derived from migrating towards protocol IEC 61850 in all high-power substations in Colombia. In this context, CODENSA has conducted pioneering work by already completing protocol migration in 35% of all its substations (at a station-bus level) and also by currently running migration processes in the remaining substations (fully implemented by 2016).

The present study describes best-practice activities that have been identified as necessary in order to achieve sustainability for the aforementioned laboratory in the midterm. The evidence suggests that it is possible to accelerate the whole process so that the laboratory becomes first of its kind to be certified in South America. Certification will facilitate the adoption and exploitation of new technologies associated to intelligent grids and digital substations in the Colombian electrical-power sector.

Good-practice activities have been identified by means of a relative comparison process (benchmarking) and so best-practice has been categorized as those activities that meet all the defined criteria following the predefined prioritizing methodology. The final result allows identification of best practice that should be adopted at the laboratory in order to accelerate the process towards the laboratory's wide recognition in South America in the midterm.

Additionally, the findings allow identifying new uses and applications of the knowledge that emerged from the process itself, which contributes to consolidate the laboratory within an international IEC-61850-standard ecosystem. This represents a key step towards facilitating the creation of new electrical products accepted by global markets.

INTRODUCTION

In Colombia in 2013, Codensa together with Universidad Nacional identified the need to create a new role (new actor) within the commissioning processes involving power substations where standard IEC 61850 was being adopted as a key element to enable the use of new smart-grid technologies applied to electrical substations (digital substations). The first stages of this initiative included enabling the basic infrastructure, which consisted of software tools (associated to requirement- and parameter-validation), measurement instructional guidelines, staff training programs, and the setup of equipment (equivalent to the existing equipment at CODENSA power substations, migrating towards standard IEC 61850 – by the end of 2013, 100% of CODENSA substations had adopted up to 35% of standard IEC 61850 at a Station Bus level). During the laboratory setup stage, it is necessary to identify the best practice that can be applied to the laboratory operation regarding standard IEC 61850. Promoters of this initiative were totally convinced that early adoption of such best practice when operating should lead to accelerating the consolidation process as well as guaranteeing sustainability in the midterm; considering that the laboratory's goal is to become the first Level-A certified lab in South America by the end of 2014. The present study follows a methodology by first identifying particular practice that has been applied to similar engineering laboratories (comparable to the Colombian laboratory in question) and subsequently by establishing proper assessment criteria that leads to defining an impact matrix and so helps to estimate the necessary efforts to achieve a successful adoption of such practice. Based on the analysis of our results, it is possible to identify the type of practice (activities) regarded as the best. The final part of the paper includes a detailed description of the already identified best-practice activities together with their theoretical supporting analysis.

GOOD-PRACTICE IDENTIFICATION

Following the current competitiveness global trends aimed at identifying strategies and procedures that serve as model experiences or starting points (to establish customized models), it is convenient to identify the kind of good practice that is carried out within the electrical-substation automation-laboratory sector, even some practice form outside this sector [1].

There are various criteria that allow identifying good practice, namely:

- Innovative component: practice that finds novel ways of addressing particular (already-defined) problems.

- Pertinence: practice that contributes to solving a problem or meeting a particular need that has been identified as a priority. This type of practice lies in strategies that meet the needs and suit the particularities of a given context.

- Repeatable, tested, and defined methodologies: good practice must include methodologies that have been carefully selected in order to transform a priority situation. Such methodologies have been already tested or, at least, under thorough assessment.

- Visible, measurable results: good practice experiences rely on clear results, which are commonly measurable and easy-to-verify. In an ideal situation, these results are sustainable and include strategies to keep up transformations.

- Ability to transfer learning experiences: good practice includes a considerable set of reflections and fundamental learning accounts where the experience gained from overcoming mistakes becomes an asset, and so adjustments have been applied whenever necessary. It is always possible to learn from such learning accounts and also to transfer knowledge to the different contexts where intervention is intended.

In summary, good practice allows the following: on the one hand, learning and revisiting elements in order to substantially improve the current way of doing things; on the other hand, showing the way towards exploring and starting unknown projects/paths.

A starting point to identify existing practice consists in revising current practice at institutions with fully-operating laboratories that have been recognized worldwide [2].

Table 1 shows a list of the laboratories that were observed to conduct a survey of good practice:

IEC 61850 LABORATORIES
•Cepel (Brazil) •KTL (South Korea) •Next-Generation Power Technology Center (South Korea) •NPP Mikronika Limited Company (Russia) •KETOP (China) • Nari Elect (China) •CPRI (India) •TÜV SÜD AG (Germany) •RWTH Aachen University (Germany) •KEMA (Netherlands)

Table 1. World-class certified laboratories selected for assessment regarding compliance with protocol IEC61850

These laboratories underwent assessment of their public information in order to identify various elements that may be considered as common practice. Subsequently, an identification process was conducted in an attempt to capture the kind of practice that is typical of the laboratories from the list, which allows having a first approach to potential practice that might be considered good practice (see Table 2 for a summary).

TYPE OF PRACTICE	AMOUNT	PERCENTAGE
MANAGERIAL	15	33%
LEARNING	8	17%
TECHNICAL	23	50%
TOTAL NUMBER	46	100%

Table 2 Summary of good practice elements observed in certified laboratories worldwide in order to complete compliance tests regarding protocol IEC61850

Based on the whole work, various practice activities were identified and categorized into three different groups, namely: good managerial practice, good learning practice, and good technical/operational practice [3]. The following is a presentation of the most relevant practice activities (elements) in each group:

Good managerial practice

Management is considered as the kind of practice that is associated to administration systems, considering widely accepted international regulations such as ISO standards.

This list of elements (practice in use) is considered as managerial according to the definitions found in standard ISO 17025[4].

Good learning practice

In engineering, typical laboratory practice implies a similar connotation to that of the workshops associated to other disciplines. A workshop is defined as a methodological strategy, intended for group work that extends the scope of mere concept learning, thus allowing integration of theory and practice at the same level; this is achieved by emphasizing the "hands-on" learning. Thus, two essential elements must be provided by good laboratory practice, namely: the teaching of thinking skills together with hands-on learning.

Specialists and researchers in the field of science pedagogy claim that it is convenient to leave the notion of using "a teaching method" and use a "learning strategy" instead. A learning strategy is better fit to suit the newer alternative approaches (not traditional methods) and its organization necessarily leads to significant learning. These alternative approaches outperform learning models that are based on plain knowledge-transmission and mechanical learning as the only way to acquire new knowledge, since in the latter there is no establishment of the appropriate "subsunsors" for actual learning [5].

These teaching strategies are consolidated by "performing activities where certain basic information obtained from reliable sources is handled through concrete procedures that are associated to given pedagogic media according to motivational goals (either internal or external)"

Due to its practical and applied orientation, laboratory practice should have a direct correlation with the so called "know-how", which pertains to constructivist models such as that of Perkins [6], Raths [7], among others. This practice should also start from the significant-learning vision stated by Ausubel[8], which implies full comprehension as well as organization of new knowledge together with previous knowledge (fitting process) to finally yield a hierarchical approach to all knowledge, which allows successful concept interrelations that lead to the expected acquisition effect.

The practice elements categorized in this group are mainly oriented towards continuous improvement within a quality management system.

Good technical practice

This group (category) relates the kind of operational practice associated to the tests that should be carried out in the various trials

IMPACT-EFFORT ASSESSMENT

The impact of implementing good practice can be determined by adopting a two-state discrete scale, namely a HIGH-LOW scale. Grades are obtained according to two variables, namely IMPACT and EFFORT. "Impact" is associated with the ability to improve performance in a laboratory, where HIGH is awarded when there is a dramatic change; LOW is awarded if there is a gradual change. On the other hand, the word "effort" is associated with easiness to adopt a particular type of practice, in this case, HIGH is awarded if practice adoption requires radical changes, and LOW is awarded when practice adoption implies gradual changes.

Good managerial practice

Assessment was carried out considering the criteria of expert leaders in engineering laboratories (directors), who are certified to perform compliance tests according to standard IEC61850 [9]. The criteria as well as their impact-effort relations are described in Table 3.

MANAGERIAL PRACTICE			
ITEM	DESCRIPTION	IMPACT	EFFORT
1	LIABILITY	HIGH	LOW
2	MANAGEMENT SYSTEM COVERS WORKERS OUTSIDE THE LAB	HIGH	LOW
3	EARLY IDENTIFICATION OF INTEREST CONFLICTS	LOW	HIGH
4	PROOF OF INDEPENDENCE CAPABILITIES	HIGH	HIGH
5	PROTECTION OF CONFIDENTIAL INFORMATION	HIGH	LOW
6	DEFINITION OF ORGANIZATION ASSOCIATED TO TESTS	LOW	HIGH
7	INCLUDE TOTAL TECHNICAL RESPONSIBLE PERSONNEL	LOW	LOW
8	QUALITY RESPONSIBLE PERSONNEL WITH HIGH-LEVEL ACCESS	HIGH	HIGH
9	BOARD-OF-DIRECTORS INVOLVEMENT IN POLICY MAKING	LOW	HIGH
10	INCLUSION OF MANAGEMENT SYSTEM	HIGH	LOW
11	MANAGEMENT POLICIES INCLUDED IN QUALITY MANUAL	LOW	LOW
12	ALL PROCEDURES ARE TO BE DOCUMENTED	LOW	HIGH
13	SATISFACTIONSURVEYS	HIGH	HIGH
14	DOCUMENTATION CONTROL INCLUDING VERSION CONTROL	HIGH	HIGH
15	APPROVAL FOR DOCUMENTS AND MEASURE HISTORICAL RECORDS	HIGH	LOW

Table 3 Impact-effort relations for implementation of best managerial practice at a laboratory in Colombia

Good learning practice

Assessment was carried out by following a procedure similar to that of good managerial practice. Table 4 shows a list of relevant items that represent learning practice.

LEARNING PRACTICE			
ITEM	DESCRIPTION	IMPACT	EFFORT
1	PERSONAL TRAINING ON A REGULAR BASIS	HIGH	LOW
2	PERSONNEL CERTIFICATION VALIDATION	LOW	LOW
3	LEARNING-GOAL CHECKS (METHODS)	HIGH	HIGH
4	TECHNICAL MEASURE DEVIATION VALIDATION	LOW	LOW
5	CYCLICAL INTERNAL AUDITS	HIGH	HIGH
6	CHECKS ON OPINIONS AND CONCEPTS FROM TECHNICAL EXPERTS	LOW	HIGH
7	QUALIFICATIONS AND PROGRAMS IN FORCE INTENDED FOR CERTIFICATION	HIGH	HIGH
8	UP-TO-DATE TRAINING PROGRAMS	LOW	LOW

Table 4 Impact-effort relations for implementation of best learning practice at a laboratory in Colombia

Long-term sustainability

Finally, Table 5 shows the items associated with the type of technical practice that is considered as essential for any laboratory to fulfill a certification process regarding full compliance with a particular set of regulations (a standard) [10].

TECHNICAL PRACTICE			
ITEM	DESCRIPTION	IMPACT	EFFORT
1	ADEQUATE WORKING ENVIRONMENT	HIGH	LOW
2	TEST-EQUIPMENT CALIBRATION IN FORCE	HIGH	HIGH
3	PERSONAL GEAR AND PERSONNEL DRILLS	HIGH	LOW
4	CROSS-CONTAMINATION PREVENTION METHODS	HIGH	HIGH
5	NEATNESS AND TIDINESS CONDITIONS DEFINITION	LOW	HIGH
6	MEASURE UNCERTAINTY DOCUMENTATION ESTIMATION	LOW	HIGH
7	USE OF METHODS ACCEPTED BY CLIENTS	HIGH	LOW
8	PREFERENCE FOR NORMALIZED METHODS	LOW	HIGH
9	INTER-LAB RESULTS COMPARISON	HIGH	HIGH
10	DATA CONTROL FOR EXTERNAL REPLICATION	HIGH	LOW
11	INSTRUMENT CALIBRATION PROGRAMS	HIGH	LOW
12	UNIQUELY IDENTIFIED EQUIPMENT	LOW	HIGH
13	SAFE INSTRUMENT MANIPULATION PROCEDURES	HIGH	LOW
14	ISOLATION OF NON-COMPLIANT-MEASUREMENTS EQUIPMENT	LOW	LOW
15	CALIBRATION-EXPIRY-DATE LABELING	HIGH	LOW
16	PATTERN EQUIPMENT TRACEABILITY	LOW	HIGH
17	CALIBRATION AT CERTIFIED LABS	HIGH	HIGH
18	DIVERSE RESULT CORRELATION	LOW	HIGH
19	PREDEFINED TEST-REPORT DELIVERY	HIGH	LOW
20	CONTEXTUAL NAMES	HIGH	HIGH
21	GOOSE-MESSAGES INPUT/OUTPUT INFORMATION	HIGH	HIGH
22	IEDS PREVIOUS INVENTORY	HIGH	LOW
23	SELECTION AND DRAGGING METHOD FOR DATA INPUT	LOW	HIGH

Table 5 Impact-effort relations for implementation of best technical practice at a laboratory in Colombia.

METHODOLOGY

The methodology followed in the present study consisted in performing a comparative assessment of various institutions to subsequently identify the kind of practice that is observed as recurrent. From this set of practice elements, validation occurred for those elements that bear a clear relation with the result-based indices found in current literature. Out of this set of good practice elements, further validation is applied to those that represent profound impacts and involve an appropriate balance in terms of the necessary efforts for successful completion.

RECOMMENDED BEST PRACTICE

The type of practice that lies in the high-impact low-effort zone represents those practice elements (activities) that should be adopted promptly (first priority). In a second stage of continuous improvement, the practice elements that entail high impact and high effort should be addressed. Thus, a sustainable (long-lasting) roadmap can be identified and adapted to the expectations set in the laboratory's strategy.

Figure 1 shows various initiatives (with their corresponding numbers) and their location within a matrix, which allows identifying the best practice to be recommended.

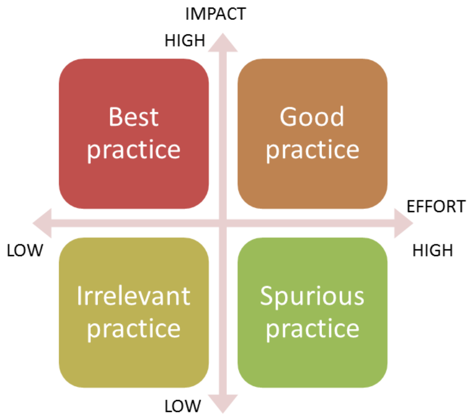

Figure 1 Impact-effort matrix for identification of best practice to be recommended in the implementation of a certified test laboratory intended to assess protocol-IEC61850 compliance in Colombia.

The following is a list of first priority practice elements according to the present methodology (Figure 2)

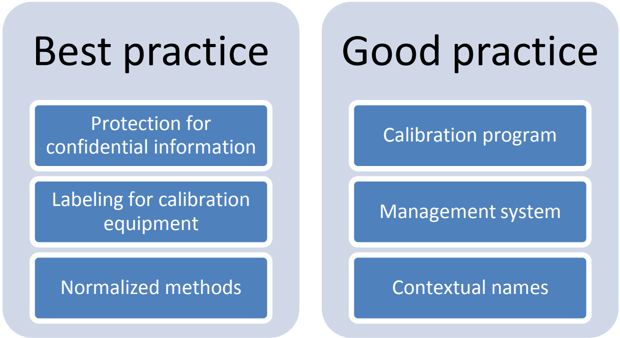

Figure 2 Identification of best and good practice to be recommended for implementation of a certified test laboratory (protocol-IEC61850 compliance) in Colombia based on the results from the impact-effort matrix.

CONCLUSIONS AND RECOMMENDATIONS

The results allow establishing a clear roadmap for the adoption of best practice, which stems from suitable identification of relevant characteristics for any laboratory that may be interested in accelerating its continuous-improvement process. In the particular case of the IEC-61850-compliance laboratory implemented in Colombia, the present study indicated a path towards sustainable development in the midterm.

The best practice elements identified herein can be adopted by various engineering laboratories that face challenges similar to those defined by the promoters of the IEC-61850-compliance laboratory.

ACKNOWLEDGMENT

The authors gratefully acknowledge the contributions and support of CODENSA, a company that has led the promotion and development of this study. This company has expressed a particular interest in strengthening and encouraging the implementation of the first IEC61850 certified test lab within the Colombian electric power sector.

REFERENCES

[1] IEC, Electric Power Research Institute, 2008, “IntelliGrid Methodology for Developing Requirements for Energy Systems”, *International Electro technical Commission, ISBN 2-8318-9525-1*

[2] SGN Case study, 2006, “Designing the Future”, *Smart Grid News*

[3] EPRI Report, 2012 “*Implementation of IEC 61850; A Coherent Approach to Substation Automation and the Smart Grid*” - 1021609

[4] National Association of Testing Authorities, 2013, “ISO-IEC 17025 standard application document for accreditation of testing and calibration facilities”, *NATA, Australia.*

[5] R. Driver, 1988, “ A constructivist approach to curriculum development”, . *In Fensham, P. (Ed.). Development and dilemmas in science education.* London: Falmer Press.

[6] D. Perkins, 1995, “Smart schools: From training memories to educating minds”, May. Free press.

[7] L.E Raths, S. Wassermann, 1986, “Cómo enseñar a pensar. Teoría y Aplicación. Paidos. Buenos Aires, Argentina.

[8] Ausubel, David P, 1983, “*Educational Psychology: A Cognitive View*”,. New York and Toronto: Holt, Rinehart and Winston.

[9] D. Baigent, M. Adamiak, and R. *Mackiewicz*, 2004. “*IEC 61850* Communication Networks and Systems In Substations: An Overview for Users”. SIPSEP

[10] EPRI Report – “Utility Standards & Technology Adoption Roadmap” – 1023041